Survey of Highway Freight-Hauling: State Regulatory Practices, Trucker Perceptions, and Truck Traffic Volumes

Final Report 487

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16. Abstract

This study incorporates freight hauling company concerns, perceptions and truck volume analysis in an investigation of Arizona State Highway service. It also examines what policies other states have implemented in order to identify options that may mitigate trucking company concerns. This study should be viewed as a general picture of problem areas as defined by trucking companies and truck volume analysis with ideas for what other services ADOT could provide to improve service. Options for Arizona's service are generated with geographic detail of problem locations and are provided by current state agency practices as summarized in the state agency survey analysis.

Arizona's location as a border state as well as the its recent population increases resulting in a relatively new interstate system make its situation and needs unique. This study found that different state agencies have very different restrictions on trucking as well as various means of revenue collection and regulatory enforcement. Investment in overcapacitated routes may take priority, but should be accomplished in conjunction with meeting other needs such as the North-South Canamex trade route. With increased trade for Arizona, commercial traffic will increase. Magnifying the need to accomplish both priorities—traditional capacity and safety measures and efficiency measures.

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	2.54	centimeters	cm
ft	feet	0.3048	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	6.452	centimeters squared	cm^2
ft^2	square feet	0.0929	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
mi^2	square miles	2.59	kilometers squared	km^2
ac	acres	0.395	hectares	ha
		MASS (weight)		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.0328	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3

Note: Volumes greater than 1000 L shall be shown in m^3.

		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

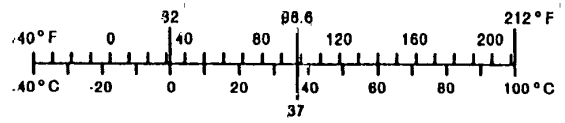
APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
yd	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
yd^2	kilometers squared	0.39	square miles	mi^2
ha	hectares (10,000 m^2)	2.53	acres	ac
		MASS (weight)		
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1000 kg)	1.103	short tons	T
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3

		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

These factors conform to the requirement of FHWA Order 5190.1A

*SI is the symbol for the International System of Measurements



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EXECUTIVE SUMMARY

This study incorporates freight hauling company concerns and perceptions in an investigation of Arizona State Highway service. It also examines what policies other states have implemented in order to identify options that may mitigate trucking company concerns. These concerns and populations were left out of previous reports (Matranga & Semmens, 2000; Hernandez, 1997; ADOT, 1998; Behavior Research Center, 2000; Radwan, *et al*, 1987). This study found that different state agencies have very different restrictions on trucking as well as various means of revenue collection and regulatory enforcement. But it also found that while other states may be moving onto other concerns such as improving efficiency of highway service, Arizona may not only need to improve highway service but also expand capacity and safety. Both of which are traditional spending priorities.

This study should be viewed as a general picture of problem areas as defined by trucking companies with ideas for what other services ADOT could provide to improve service. Options for Arizona's service are generated with geographic detail of problem locations and are provided by current state agency practices as summarized in the state agency survey analysis. To this end, this study will serve as an analytical and prioritizing tool for the Arizona Department of Transportation.

It should be noted in the trucking survey, that the responses may be biased because of the respondent's position in the companies surveyed. Thirty three percent (33%) of the returned surveys were not completed. A random sample of truck drivers taken at various truck stops might shed much different results.

Key Findings

Arizona collects vehicle classification data and annual traffic volumes, utilizing the same methods most cited by other states like axle counter and weigh-in-motion technologies. However unlike other states, Arizona does not use these technologies for regulation enforcement. Very few states had plans to promote intermodal activities. Arizona has no current specific effort to promote intermodal activities.

Freight hauling restrictions can impact transit time. Such restrictions will reduce the level of service of the highway to the freight carrier. However, Arizona, unlike many other states, has very few restrictions on hauling. This may be because most of Arizona's population is in the two metropolitan areas of Phoenix and Tucson. Arizona has no lane restrictions, but does have hourly restrictions from 7-9AM and 4-6PM (commuter hours) in the urban areas of Phoenix and Tucson. Arizona also has speed restrictions for steep grades and overweight trucks on bridges, and prohibits hazardous cargo in a tunnel on I-10 in Phoenix. In the trucking survey, carriers cited few regulatory problems overall. Those mentioned, primarily were a result of construction or congestion. Therefore regulatory hauling restrictions do not appear to adversely impact level of service.

With regard to regulation enforcement and fee collection in the various states surveyed, the preferred method was mobile units. Fixed ports of entry were also widely used. With the exception of California, those states that did utilize weigh stations did not collect fees at fixed ports of entry. Only Arizona collects fees utilizing fixed ports of entry and mobile units as well as special interdepartmental task forces. Several states also utilized weigh in motion technologies to collect fees. Arizona, like other states, has weigh stations, but they also have agricultural inspection stations and border patrol inspection stations. Thus creating more opportunities for delays and congestion at various stopping points in the system.

The major ports of entry into Arizona via other U.S. states that generated complaints from trucking companies included: Ehrenberg, Yuma, Parker, and the New Mexico – Arizona port of entry. More specifically, the cited problems found with ports of entry included congestion, poor staffing, delays up to 15 minutes, and poor port design.

In Arizona, during the five years prior to NAFTA, exports to Mexico increased 153% (Ammirati, 1999). Since the inception of NAFTA, Arizona exports have increased an additional 83% (Ammirati, 1999). However, trucking survey respondents did not cite international ports of entry as problems. According to other studies, international port design and cross-border traffic are serious issues and something Arizona has not paid much attention to in the past (Dye et al, 1999; Liu and Shinbein 1999; U.S. GAO, 1997; McCray and Harrison 1999; Haines, 1997; Canamex, 1999). From this study it is unclear how many companies do perform cross-border traffic. Therefore the issue may not be a concern for this particular trucking sample.

NAFTA has great implications for freight corridors from Mexico to Canada. As previously mentioned, McCray and Harrison (1999), showed that several corridors are apparent when trade flow routes from Mexico and Canada are combined. Canamex, Arizona's North American trade route, extends from Nogales, Arizona and continues through Nevada, Utah, Idaho, and Montana. Canamex is currently involved in infrastructural improvement plans to create an I-19 and I-10 bypass, expand intermodal and warehousing facilities, increase capacity along US 93 as well as a new rail port of entry in Naco, Arizona (Canamex, 1999). Future ADOT research should focus on the needs of the commercial cross-border traffic user group.

Roadway Problems found in this study included poor pavements, congestion along specific segments particularly in urban areas, and decreased safety along specific segments due to a lack of signage, capacity, turnouts, and poorly equipped rest areas. Arizona's participation in a pavement demonstration project may in the future lead to better pavements. However, Arizona's allowance of longer combination trucks increases wear on pavements, and reduces safety (U.S. GAO, 1993). The majority of problems occurred in the highly trafficked urbanized areas of Phoenix, and the commercial routes like I-10 and US 93.

This study also found that certain non-interstate routes are important commercial traffic routes and have volume / service ratios as high as 1.19. This is in agreement with many of the complaints cited by the trucking companies that participated in the survey. These roadways include: US 93, US 60 Between Phoenix & Wickenberg, AZ, US 89 by Page, AZ, State Route 85 between I-10 and I-8. All of these routes have only two throughlanes, and yet 22 to 41% of the daily traffic volumes on these segments are commercial truck traffic. This lends credence to the argument that Arizona is primarily rural in nature, particularly in its transportation network. These routes as well as the major interstates, I-10, I-17, and I-40 are slated high priority roadways for capacity improvements. Medium priority routes include: State Route 77, State Route 66, State Route 260 by Payson, State Route 188, State Route 90, State Route 87 by Payson, State Route 89 between Sedona and Flagstaff, and US 60 east of Phoenix. The remaining low priority routes have volume/service ratios from only 0 to 0.3 and are not major commercial routes.

This research also found that state agencies' methods to expedite the collection process can be divided into three categories. The first tier states have implemented web page payment systems, accept credit cards, and use Commercial Vehicle Information Systems Networks to electronically track permits and identification with neighboring states. This second tier group utilizes such items as credit card payment, automatic vehicle identification, and prepass systems, but has not progressed to the internet. The remaining states either have plans for the aforementioned methods or simply use the court system, the state patrol, and payment with registration through the department of transportation. The third tier states are primarily states with smaller populations and so may have limited resources to implement such collection methods.

Arizona, like the second tier group, utilizes electronic issuing systems, credit card payments, and escrow accounts in expediting the permit and regulation enforcement process. However unlike other states in this group they do not use automatic vehicle identification systems or prepass systems. While ADOT has a web page, it is not at this time used to enforce regulations, obtain permits or assist in expediting the permit process in any way. Arizona obviously still has a long way to go in the electronic age. Many trucking companies have access to the internet and email as evidenced by the trucking survey. Saving companies further time and money by utilizing the web to expedite regulation processes would go a long way in serving companies' needs.

The transportation industry has changed as a result of a highly competitive global market and thus affected Arizona as well. International trade and transportation agreements have helped global commerce flourish, but today's market depends upon efficient logistics, customer service, and just-in-time inventory systems. Business wants high-quality transportation service that is speedy, flexible, competitively responsive and low cost. Optimal efficiency is the goal of the future rather than constructing new roadways (Williams and Hoel, 1998). Planning models and economic equilibrium models in future will be used to assess highway service, plan for freight efficiency, and result in reducing transport operation costs particularly those associated with congestion (Williams and Hoel, 1998). Methods such as congestion pricing, increasing road

capacity, use of electronic data interchange, automated international border clearances and improving intermodal efficiency are the latest developments of transportation service improvement (Golob and Regan, 1999). However, as shown in this research, Arizona not only needs to increase efficiency by redesigning ports of entry, reducing congestion and traffic management, but it also needs to increase capacity along particular road segments such as U.S. 93 and certain parts of I-10.

Clearly Arizona's location as a border state as well as the its recent population increases resulting in a relatively new interstate system make its situation and needs unique. Investment in overcapacitated routes may take priority, but should be accomplished in conjunction with meeting other needs such as the North-South Canamex trade route. With increased trade for Arizona, commercial traffic will increase. Magnifying the need to accomplish both priorities—traditional capacity and safety measures and efficiency measures.

INTRODUCTION

The objective of this study is to incorporate freight hauling company concerns and perceptions into an investigation of Arizona State Highway service with particular regard to freight hauling as well as examine what policies other states have implemented to identify options that may mitigate trucking company concerns. Previous studies of highway service have taken a top-down approach and focused solely on physical measures such as pavement performance, level of development of highway segments, capacity and volume, traffic counts and the percentage of commercial traffic (ADOT, 1998). The state has not performed a study in the past asking the actual users of the state highways where the system is lacking or needs improvement. This study will survey freight hauling trucking companies that utilize Arizona's state highway system to assess their perceptions and needs. Interviews of transportation experts will also be included where pertinent to the analysis.

The most recent published documents on Arizona highway service have been reports rather than analyses (ADOT, 1998). The 1998 Status & Condition Report merely presented the data from 1996 including the annual average daily traffic volume, commercial vehicles on the state highway system, bicycle suitability, functional classification, level of development, level of service, and present serviceability rating. While three of these measures are combinations of other measures, they are all physical measures. Level of service is similar to the volume-capacity ratio. This ratio represents the demand flow rate (volume) to capacity. It also utilizes certain qualitative measures describing driving conditions. Level of Development is a hierarchical ordering of road segments. Level of development takes into account the segment's functional classification, level of significance, daily traffic, and truck traffic. The present serviceabilty rating represents abnormal variations in the road surface which are collected via machine. These measurements indicate the smoothness or roughness of the pavement. While it reported all these measures there was no effort in the report to assess problem areas or areas needing improvement as a result of all the measures taken. It also did not account for user perception.

Another report conducted by ADOT, Arizona Highway User Origin and Destination Survey reported characteristics of Arizona's highway users and their most frequently utilized routes to their most frequently visited destinations (Behavior Research Center, 2000). The study's primary focus was the origins and destinations of Arizona residents. The survey sample included 3,210 Arizona residents and fourteen (14) commercial organizations (either companies such as Safeway or commercial freight carriers). However again this is just a report. The findings are merely presented and no analysis is provided regarding highway service. The most salient facts provided by this survey of highway users are that I-10 and I-40 are the most heavily traveled highways by non-Arizona residents and I-10 has the most commercial traffic (42%) followed by I-17 (13%) and US 60 (10%). This is in direct contrast to another report regarding Traffic and Expenditures on Arizona's State Highways (Matranga & Semmens, 2000). This report, based on traffic counts and vehicle classification, found that the most heavily trafficked highways were I-10 and I-40. The aforementioned study also analyzed revenue to expenditure ratios for each route segment in order to aid future infrastructure investment decision-making.

A previous study undertaken on Arizona's freight networks, included attitudinal surveys of freight carriers (Radwan, *et al*, 1987). However the primary objective of this survey was to

utilize it in a simulation of freight flows to assess the potential freight movement impacts on traffic congestion, highway safety, and pavement maintenance. While the attitudinal survey revealed that inferior pavement and delays at intermodal changes were major concerns, the study did not reveal where they were nor to what degree each were important. Rather than focus on commodity freight flows like the Radwan (1987) study, this study investigates freight carrier perceptions of the level of highway service and where it is lacking.

Lastly, a 1997 study reporting highway quality surveyed 2,000 residential users and 200 community leaders (Hernandez, 1997). This report found that 62% of residents and 53% of community leaders found major highways excellent or good, and 58% and 47% of residents and community leaders respectively rated freeways as excellent or good. This study also asked respondents generalized opinions and did not distinguish between specific routes and route segments. In addition, a vital group of users is left out of the survey, commercial freight haulers. since many residents may only travel within their immediate vicinity, it does not give an accurate picture of problems that may exist on rural highways. Commercial haulers, on the other hand, may travel over much of the state utilizing different routes depending upon their destinations. In contrast to their overall satisfaction with highways and freeways, residents also placed highway improvements—highway widening, pavement improvements, and safety features on highways, as their top three transportation spending priorities. Community leaders also placed highway concerns at the top including: widening highways, pavement improvements, building new freeways, and pavement markings on highways. However the survey report did not examine why these improvements were believed to be necessary by the satisfied survey sample.

Freight Transportation

The public sector has traditionally focused on highway system improvements that increase capacity and safety. However, the transportation industry has changed as a result of a highly competitive global market. International trade and transportation agreements have helped global commerce flourish, but today's market depends upon efficient logistics, customer service, and just-in-time inventory systems. Business wants high-quality transportation service that is speedy, flexible, competitively responsive and low cost. Murphy and Hall (1995) showed that in the 1990s, reliability, and transit time were more important than freight rates, possibility of damaged goods and customer service in selecting a motor carrier. Freight carriers and other transport providers have responded by improving their reliability and transit time. To meet customer needs, the public sector should also respond by improving their service to meet these specific market demands.

Williams and Hoel (1998) argue that planning for optimal efficiency is the goal of the future rather than constructing new roadways. They conclude that new analysis methods are needed to model multicommodity flows and integrate planning models with economic equilibrium models. These should be used to assess highway service, plan for freight efficiency, and result in reducing transport operation costs particularly those associated with congestion (Williams and Hoel, 1998). In doing so, the public sector could assist in business and transportation competitive markets.

Greater public sector involvement in improving highway service is being demanded by freight carriers. Golob and Regan (1999) surveyed trucking companies in California to find preferred policy responses to congestion. They found that the most cost feasible methods were improved traffic management, and signal coordination. However, these methods were only supported by small carriers. Support for other methods was dependent upon carrier type. Just-in-time carriers, short haulers and household goods movers supported congestion pricing. Short haul operators supported strategies to increase road capacity. Long haulers, private fleet, truckload and tank operators did not support increasing capacity. Dedicated truck facilities like a single freeway lane or surface street lane to truck traffic, and truck-only streets for access to ports, rail terminals and airports, were favored by users of intermodal rail and maritime facilities, common carriers, and operators engaged in just-in-time deliveries. Users of rail, air, and maritime intermodal facilities, and carriers engaged in long haul operations supported operational efficiency improvements such as intelligent transportation systems, advanced vehicle clearance systems at weigh stations and international border crossings, and truck-only streets for access to ports, rail terminals and airports. Household movers and common carriers favor policies which allow trucks to pre-empt traffic signals, parking bans on some streets, and truck-only lanes on surface streets.

From these examples the public sector is taking a greater role in serving freight transportation needs. Whether this is the result of having no highways to build or the response to a more competitive market is not the concern of this study. The concern of this study is to respond to freight transportation needs by first assessing what and where those needs are in order to better serve freight carriers.

Freight Hauling Restrictions

Freight hauling restrictions such as weight, vehicle size, lane restrictions, and time restrictions and commodity restrictions can impact transit time, and intermodal changes between states. Such restrictions will reduce the level of service of the highway to the freight carrier. For example, weight can impact the infrastructure creating greater stress on pavements, and greater cost to the system as Hewitt *et al* found in Montana (1999). Four scenarios with different allowable maximum gross vehicle weights of up to 128,000 lbs. were studied and analyzed with regard to system performance, safety, transportation costs and changes in the number of trips. In their investigation, they found that if these maximum weights were enforced as policy transportation costs would rise 50%, and increase far more than the infrastructure costs of maintaining the roadways at current allowable gross vehicle weights. Transportation costs were dependent upon industry and increased for heavier weight industries such as milk, cement, and fuel. Infrastructure costs also increased in all but one case. It was found that a heavier truck bearing wheat caused more damage than several trucks hauling the same cargo at the 80,000 lb. limit. In addition, regulating these restrictions, particularly weight, can create time delays of up to 20-30 minutes in a 2 hour observation period as evidenced in Illinois (Benekohal *et al*, 1999). However 30% of the trucks in the study were never inspected at the weigh station, because the weigh station in response to the queue of waiting trucks allowed 30% of the traffic to move on without inspection. This practice has serious implications and consequences such as overweight trucks, damaged pavements and infrastructure, illegal immigration and smuggling concerns.

Jessup and Casavant (1996) investigated weight violations in Washington state. Of all all the vehicles in the study 20% were overweight at three test locations. They found that 81% of violations were occurring at permanent scale houses versus 19% at portable scales at varied locations. They also found through the use of weigh-in-motion technologies that weigh station avoidance was not a significant problem. The collection of such fines was only found to be a problem with in-state carriers. Sixty-two percent of violations were paid without contest; however, these were primarily from out- of-state carriers. Curiagin (1997) also examined weigh station avoidance utilizing four different enforcement strategies: scales open with no citations, scales open with citations issued at scales, scales open with enforcement on bypass routes both issuing violations, and scales open for a short period with enforcement on bypass routes, and rest areas. He found that the most violations occurred from midnight to 6:00AM and the lowest levels from noon to 6:00PM. The study concluded that only intensive enforcement reduced violations to low levels.

Arizona, like other states, has weigh stations. Arizona also has agricultural inspection stations and border patrol inspection stations. Thus there are more opportunities for delays and congestion at various stopping points in the system.

Pavement Performance

Pavement performance can hinder or help highway service. Aging pavements can result in increased congestion, delays, reduced safety, reduced service, pollution, and even catastrophic failure resulting in collapse of the pavement (Owusu-Antwi, 1999). It is necessary to monitor roadways utilizing mechanized profilers that measure the roughness of roads and rate it

according to an international standard. With pavement condition analysis programs, states have the ability to better manage maintenance projects. Arizona's condition analysis program utilizes these roadway ratings to prioritize maintenance projects.

New technologies and design techniques are also making a difference in pavement performance, particularly in preventive maintenance. A preventive maintenance program can be more cost effective because it addresses light deterioration, retards progressive failures, and reduces the need for routine maintenance activities. It also extends the functional life of pavement by applying treatments before deterioration requires a corrective treatment. Preventive maintenance strategies for both low and high volume roads have been successful. Preventive maintenance treatments for flexible pavements include fog seal, chip seal, slurry seal, microsurfacing, crack treatment, and thin hot-mix dense, open and gap graded overlays (Zaniewski and Mamlouk, 1999).

Demonstration projects in several states have been implemented as part of a preventive maintenance study sponsored by the Federal Highway Administration. One or more projects are underway in Colorado, Utah, Michigan and Arizona. Arizona contains three project sites: State route – 260 near Show Low, U.S. – 180 near Springerville, and U.S. – 93 near Kingman (Zaniewski and Mamlouk, 1999). Each project evaluates the effectiveness of preventive maintenace treatments on pavement performance. The study showed that a specific treatment's performance is related to the condition of the pavement at the time the treatment was applied. Treatments applied to pavements in good condition have good results.

This study does not duplicate the pavement priority analysis in Arizona. However, the condition of the pavements on Arizona's roadways will be examined to the extent necessary in an overall study of freight hauling needs. Arizona, like other western states, allows longer combination trucks or LCVs of all three types including: LCV doubles, rocky mountain doubles and triples (U.S. GAO, 1993). These LCVs have been shown to increase wear on pavements, reduce safety and increase weight violation rates (U.S. GAO, 1993; Jessup & Casavant, 1996). Therefore, while pavement performance is certainly a necessary piece of Arizona's highway freight service, it will not be examined in full detail, but merely as a part of Arizona's overall service.

Intermodalism

The interchange points where freight is moved from one mode to another are the weakest links in the national transportation system (Reed, 1996). But in response to business competitiveness, intermodal freight changes are expected to grow at a rate of 13% per year (Clarke, *et al*, 1996). Impediments in efficient intermodal changes can be infrastructural such as poorly located terminals, inadequate size, capacity, layout or access, or operational impediments including a lack of technology like electronic data interchange, or preclearancing, poor coordination of modes, and inadequate operating hours. Impediments can also be regulatory, financial and institutional in nature such as long waiting periods for permits, incompatible size and weight regulations, partial funding of ISTEA for intermodal projects, and the public and private sectors' different or conflicting objectives, priorities and timing (Reed, 1996; Dept. of Transportation, 1995). Intermodal terminals may be poorly located in urban areas without

adequate capacity, pavements, or maintenance. They may also have outdated equipment for managing shipments, or lack electronic data interchange. The last three impediments mentioned have more to do with the slow process of planning than the intermodal points themselves. Many of these inadequacies such as equipment age, terminal location, and the number of vehicle miles traveled are also reflective of highway safety creating a further problem in freight service. Freight carriers' perceptions of intermodal points will be examined as part of the survey. The intent is to find out where the inferior intermodal points are and why they are inferior.

NAFTA and the Impact of the U.S. Mexico Border on Freight Hauling

Since the 1980's, cross-border freight traffic from Mexico to the United States has increased primarily because of the Border Industrialization Program. Established in 1965, this program allows foreign companies to own and operate factories in Mexico and import duty-free equipment and components, if resulting products are exported. (South, 1990). Maquiladoras, or maquilas, are manufacturing plants (primarily assembly) that operate under this agreement.

Since the North American Free Trade Agreement (NAFTA) in 1994, trade flows between the U.S. and Mexico have increased dramatically. From 1994-1996, Mexican trade with the partners of NAFTA rose 67%, while trade with other countries only rose 27% (Riner & Sweeney, 1998). This increase in trade is the result of continued and increased investment in maquiladoras. As of 1999 there were 3,051 maquiladoras employing 1.04 million workers (*The Economist Intelligence Unit*, 1999). From 1998-1999 exports from the maquiladoras increased by 26.3% while non-maquila exports increased only 3.9% (*The Economist Intelligence Unit*, 1999). In that same time period, imports to the maquiladora sector increased by 27.8% while non-maquilas increased only by 4.1%. In November 1998, 91.8% of all exports were manufactured goods. The most recent figures covering the largest period of NAFTA, 1993-1998, showed an increase in maquiladora exports of 135% (Carrera, 1998). These trade increases are still heavily reliant upon the maquila sector because NAFTA is not yet fully phased in. Two more phases in 2003 and 2008 will eliminate tariffs on non-maquila trade in such sectors as oil, steel tubes, non-automotive harnesses, electric capacitors, tiles, glassware, and agricultural products among others (Euromoney, 1995). Previous phases removed tariffs on goods such as automobiles, televisions, and computers.

In Arizona, during the five years prior to NAFTA, exports to Mexico increased 153% (Ammirati, 1999). Since the inception of NAFTA, Arizona exports have increased an additional 83% (Ammirati, 1999). All this increased trade, of course, means greater demands upon transportation systems in all the border states. Transportation is vitally important to maquiladoras, particularly those engaged in just-in-time production systems (South, 1990; Stank & Crum, 1997). Fawcett (1992), in his study of maquilas utilizing trucking, concluded that although transportation costs are higher for the maquiladora operation, companies are willing to forego this extra cost in order to take advantage of the maquiladora's benefits – namely low labor costs. Forty percent of the managers surveyed said their transportation costs were equal to or less than their U.S. facilities' transportation services. The remainder surveyed claimed the cost was only slightly higher. However in terms of information services such as transit time, equipment coordination, and documentation, performance decreased significantly.

However, several factors can hinder the ease of transport and "increase" the friction of distance. Electronic Data Interchange is utilized by many companies as well as maquilas to track just-in-time shipments (Kuby & Reid, 1992; Horowitz, 1990). This system tracks international transactions quickly and reliably via computer and has even been found to reduce the time spent awaiting clearance from U.S. customs at the border. Ford Motor Co. uses this system for both train cargo and truck freight to expedite the clearance process (Horowitz, 1990).

Smaller companies report that trucking is more expensive than train because Mexico regulations force companies to use a national trucking company. Therefore a company would have to use their trucking in the U.S. and a Mexican trucking company in Mexico, unless they can affiliate themselves with a Mexican trucking company (Horowitz, 1990). Currently in many border city pairs, U.S. trucks heading south may cross the border and change to a Mexican carrier and Mexican trucks heading north may cross the border and change to a U.S. carrier. U.S. trucks can travel 26 miles from the border and Mexican trucks also may only pick up or deliver freight within a limited area.

Under NAFTA, the border will eventually be opened to trucking companies from both the U.S. and Mexico; any company may be used in either country (Maltz, et al., 1996; Sutter, 1996, 1997). Originally set to open in 1995, it is still delayed by lobbying from protectionist transportation organizations claiming safety concerns. U.S. and Mexican regulations regarding weight size, length and width do not correspond. There is a concern that many Mexican carriers are overweight. Regulations between the two countries differ greatly (U.S. GAO, 1996). The U.S. limits trucking hours of service to ten hours daily while Mexico has no limits. Mexico also do not require logbooks or front breaks on their carriers. Both are required in the U.S. In addition, Mexico's maximum legal weight is 97,000 pounds; 17,000 lbs. greater than U.S. regulations. Fifty percent of the trucks from Mexico at four border states did not meet U.S. regulations (U.S. GAO, 1996). It was also found that 80% of tridem axle loads and 35% of tandem axle loads from Mexico were overweight (Harrison et al, 1998). Arizona found that 63% of inspected trucks from Mexico in 1994 were put out of service while the statewide average for trucks from all origins was only 24% (U.S. GAO, 1996). Others cite immigration concerns with regard to the operator and illegal migrant transport. The Mexican government has similar safety concerns regarding vehicle length.

Several inefficiencies have been identified with border crossings regardless of the actual inspections process (Dye et al, 1999). U.S. inspection facilities were found to be the primary cause of delays in northbound traffic into the U.S., not the actual border crossing. Inspection facilities are too small to adequately inspect vehicles and too overloaded to work at capacity resulting in trucks being waived through inspections. If trucks do not get inspected, this contributes to other problems such as illegal immigration, drug smuggling, as well as cargoes containing restricted commodities and overweight vehicles. Dye, Bochner and Eckols (1999) suggest demand management practices to reduce delays. In their optimization plan, inspection facilities should be built to meet the expected demand and one large facility should be constructed rather than two smaller and costlier facilities. Liu and Shinbein (1999) take a different approach suggesting managing the traffic demand and capacity on the roadways leading up to the border crossing by diverting them to different inspection areas based on their needs. California receives 24% of the truck traffic from Mexico, and in response has opened two large

permanent inspection stations (U.S. GAO, 1997). Arizona and Texas receive more than 75% of the Mexican traffic combined and have doubled the inspection staff as a result (U.S. GAO, 1997). With 10% of the truck traffic from Mexico distributed across six ports of entry, Arizona currently has no permanent inspection facility. However the idea has been entertained at Nogales, which receives 72% of Arizona's Mexican truck traffic. However both Arizona and Texas have failed to invest in inspection facilities at border crossings citing a lack of space in urban areas. The prevailing attitude in both states is that "NAFTA is a national issue that should not be financed with state funds" (U.S. GAO, 1997).

Lastly, NAFTA also has great implications for potential freight corridors from Mexico to Canada. Having an East - West orientation in its highway transportation system, The U.S. is developing several regional transport corridors. McCray and Harrison (1999), found that several corridors clearly emerge when trade flow routes with Mexico are combined with trade flow routes with Canada. Interstate 69 is planned to extend from Laredo, Texas to Detroit, Michigan (Haines, 1997). It will pass through several economically depressed regions and impact several states' highway infrastructure. Canamex, Arizona's counterpart, extends from Nogales, Arizona and continues through Nevada, Utah, Idaho, and Montana. However not all the roadways in both corridors are interstate roadways. This necessitates expanding capacity on those non-Interstate segments. Canamex is currently involved in infrastructural improvement plans to create an I-19 and I-10 bypass, expand intermodal and warehousing facilities, as well as establishing a new rail port of entry in Naco, Arizona (Canamex, 1999). The organization spearheading the Canamex effort is presently in the planning stages of the corridor. This of course means improved service for Arizona freight. However, it would assist the planning process to determine the neediest areas and their problems, which is the intent of this study.

METHODOLOGY

The objective of this study is to incorporate freight hauling company concerns and perceptions into an investigation of Arizona State Highway service with particular regard to freight hauling as well as examine what policies other states have implemented to identify options that may mitigate trucking company concerns. This study seeks to answer questions regarding which Arizona highway segments are particular problems for trucking firms. It will also identify which problems have to do with regulations, roadways, or intermodal transfers as well as why they believe the problem exists.

State Transportation agencies will also be surveyed to identify options to assist in mitigating trucking concerns. These may be options that Arizona may not be using at this time or they may be entirely different regulatory policies.

Utilizing both surveys, options for Arizona's service will be generated with geographic detail of problem locations. To this end this study will serve as an analytical and prioritizing tool for the Arizona Department of Transportation.

Survey Instrument on State Policies

This survey was conducted by mail and had a 66% response rate (33 of 50 states responded, 4 states responded twice from different administrative units). Respondents were self-selected from all state transportation agencies. The survey asked open-ended questions dealing with three main topics: 1) Transportation Planning, 2) Truck Restrictions, and 3) Enforcement of regulations and fee collections (See Appendix A). Each section is described below.

Transportation Planning

This section included questions regarding data collection methods, types of data collected as well as data not collected that could be useful for meeting freight hauling needs. States were also asked if they take any actions to promote intermodalism and asked to describe these policies and/or projects.

Truck Restrictions

This section included a series of questions regarding state policies restricting freight haulers to particular hours of operation, designated lanes, speeds, and commodities. Respondents were asked if such restrictions existed in their state, and to describe any such restrictions.

Enforcement of Regulations

Respondents were then asked in the following section how restrictions and regulations are enforced and their methods and locations of fee collections. States were also asked whether any steps were taken to expedite regulation enforcement via technological improvements or otherwise.

Survey Instrument on Trucking Firm Perceptions

This survey was also conducted by mail to over 250 freight hauling companies and had a 12% response rate. Respondents were self-selected in this survey as well. The survey asked multiple choice and open-ended questions dealing with five main topics: 1) Carrier Background, 2) Regulatory Problems, 3) Roadway Problems, 4) Intermodalism, 5) ADOT Improvements (See Appendix B). Each section is described below.

Carrier Background

This section inquired as to the types of trucks in respondent firms' fleets including standard vans, double trailers, refrigerated units, flatbeds, cement mixers, and tanks. It also asked questions regarding length of hauls, rural vs. urban hauls, and whether their hauls are primarily within Arizona, have an origin or destination only in Arizona or just passing through Arizona. These background questions will present the carrier industry environment in Arizona as well as have implications for particular urbanized areas and pavement performance.

Regulatory Problems

Respondents were asked in this section to name the segment location along Arizona's highways that was most frequently the worst in each of the following regulatory categories: lane restrictions, hour restrictions, commodity restrictions, weight restrictions, inspection stops, and ports. Firms were also asked to describe the reason behind each problem from their perspective.

Roadway Problems

Respondents were also asked in this section to name the segment location along Arizona's highways that was most frequently the worst in each of the following roadway categories: pavement conditions, road capacity, safety, turnouts, signs, and roadside amenities. As in the previous section, firms were also asked to describe the reason behind each problem from their perspective.

Intermodalism

In this section, firms were asked questions regarding any intermodal transfers they conduct. They were also asked to state those locations that are problematic for intermodal transfers and the reason for the problem.

ADOT Improvements

Lastly freight haulers were asked what the Arizona Department of Transportation could do to improve their service in these and any other areas needing improvement.

GIS Analysis Methods

Geographic Information Systems (GIS) are utilized to map and analyze the commercial freight hauler traffic data. The data are mapped using ArcView GIS, a GIS application software from ESRI, Inc., in order to visualize where the major problem areas are in the State of Arizona. Using GIS analysis, the commercial vehicle traffic counts by highway segment from 1998 (ADOT, 2000) and roadway design data will be used to obtain an accurate picture of major problem areas.

The data analyzed in the GIS analysis is taken directly from the data collected by the Arizona Department of Transportation. These data include: the annual average daily traffic, the number of through lanes, widening feasibility, volume/service flow Ratio, the percent average daily single unit trucks, and the percent average daily combination trucks. The annual average daily commercial traffic is derived from the annual average daily traffic, the percent average daily single unit trucks, and the percent average daily combination trucks. The volume/service flow ratio is a reflection of the capacity per segment. The volume/service flow ratio is a computed value reflecting peak hour congestion for a sample section. (See Appendices E and F for definitions and procedures for data collection).

ANALYSIS AND RESULTS

This section discusses survey results, the GIS analysis and the recommendations proposed by the freight haulers and policy options garnered from the state policy survey in order to improve service to freight haulers.

State Policy Survey Results

Commonalities resulting from the survey were difficult to derive. This survey was conducted by mail and had a 66% response rate with 33 of 50 states responding (See Figure 1 for participating states). Each state has different policies regarding freight hauling service and collects different data on commercial traffic (See Appendix C for response detail). The following sections briefly discuss the range of responses as well as the most common responses on each section of the survey -- 1) Transportation Planning, 2) Truck Restrictions, and 3) Enforcement of regulations and fee collections.

Transportation Planning

The types of data collected by other states included such detailed data gathered from surveys on origin / destination flows, commodities hauled, commodity weights, truck volumes, truck classifications and vehicle miles traveled (See Table 1). These were the most common data collected. Some states also collected data on tonnage by commodity and truck type and crash data as well. Montana was the only state surveyed that collected border crossing data. In addition, Maine and Oregon were the only states to collect data on perceived problems as this study is doing. However some states such as Oklahoma, Nebraska, New Hampshire, North Carolina, Georgia and Utah, collected no data regarding freight hauling at all. Primarily the respondents utilized surveys to collect this data and some purchased data from private agencies and consultants. Many of the states are using a variety of technologies to acquire data including weigh in motion technologies, roadway monitoring data stations, and axle counters.

The majority of states needing additional data were interested in data collection that was more detailed and unique to the needs of that state (See Appendix C for response detail). Those states with common data needs wanted data that other states in the survey were already collecting such as origin / destinations, and commodities (See Table 2). However, some states would like to acquire data that none of the other states are collecting or even interested in collecting. Louisiana, for example, wants to add more geographic detail to its origin / destination data by commodity and mode. It's unclear what detail they require, whether route choice or something else. Missouri is interested in collecting data on trucking routes and freight centers as well. North Dakota currently collects agricultural flow data but wishes to add manufactures to its data set. Nevada is also interested in gathering pipeline data. Others like Wyoming, want to find out what percentage of their truck volume data are simply passing through. Data such as this would be very useful given Wyoming's location along a major trunkline in the U.S. highway system.

In contrast to the variety of data collected by other states, Arizona currently only collects vehicle classification data and annual traffic volumes. It collects this data in a variety of ways including portable electro-pneumatic equipment, handheld tallyers, continuous classifying equipment, weigh in motion devices, axle counters, and tube counts. This devices are used only for data collection however and not regulation enforcement.

Figure 1.
State Agency Survey Participation

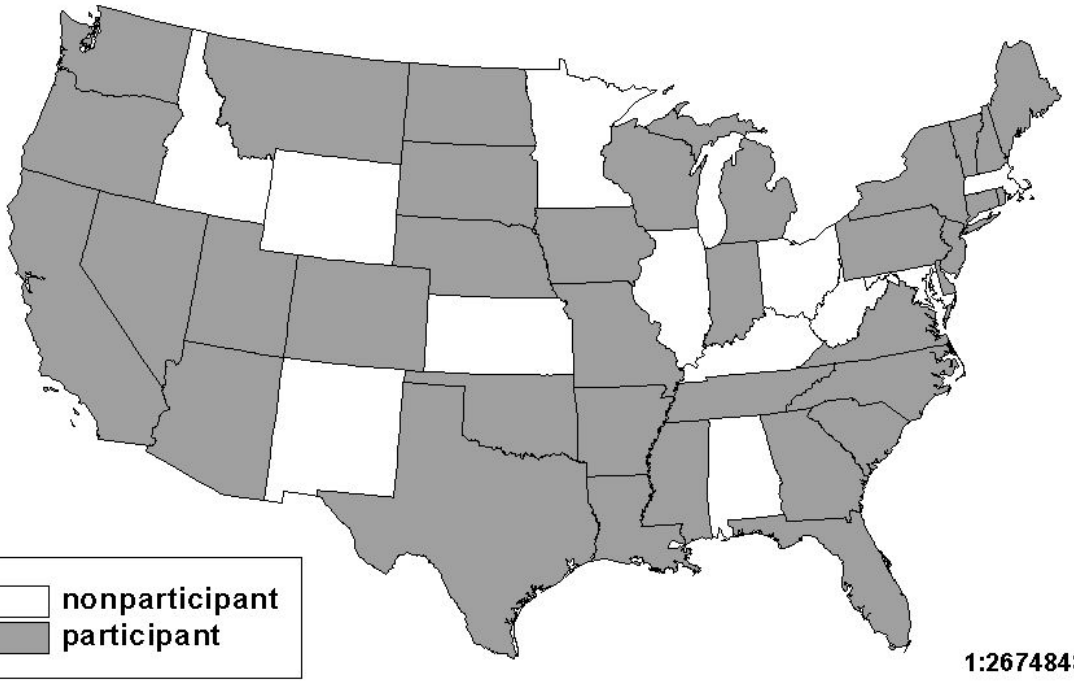


TABLE 1. Data Collected. (See Appendix C for response detail.)

STATE	Origin/ Destination	Vehicle Class	Commodity hauled	Commodity Weights	Truck Volumes	Vehicle Miles Traveled	Other
AR	*		*	*			
AZ		*			*		
CA	*	*			*		
CO		*		*	*		*
CT			*				
DE	*		*				
FL							*
GA							*
IA					*		*
IN					*		
LA	*	*					*
ME	*		*				*
MI		*					*
MO					*		
MS							
MT	*				*	*	*
NC							
ND							*
NE							
NH							
NJ	*		*				*
NV			*	*			*
NY	*		*				*
OK							
OR			*				*
PA		*		*	*		
RI							
SC		*					*
SD					*		*
TN							*
TX	*		*				
UT							
VA							*
VT	*		*	*			*
WA	*	*	*		*		*
WI		*			*		*
WY		*			*		

TABLE 2. Data Wanted but Not Yet Collected. (See Appendix C for response detail.).

STATE	Origin/ Destination	Vehicle Class	Commodity hauled	Commodity Weights	Truck Volumes	Vehicle Miles Traveled	Other
AR							*
AZ							*
CA							*
CO				*		*	
CT							
DE							
FL							*
GA							
IA	*						*
IN					*		
LA	*	*					*
ME	*						*
MI		*					*
MO					*		
MS							
MT	*		*				*
NC							*
ND							*
NE							
NH			*				*
NJ							
NV							*
NY			*	*			*
OK	*						
OR	*		*				*
PA							
RI							
SC			*				*
SD	*						
TN							*
TX							*
UT							
VA							
VT							
WA							
WI							
WY							*

There are over thirty permanent data collection sites and hundreds of temporary sites in various locations around the states. Mark Catchpole and Steve Abney of the Arizona Department of Transportation also responded that they did not know of any other data necessary to freight hauling. However, ADOT at this time has a call for proposals to investigate what types of new data it should be collecting.

States were also asked if they take any actions to promote intermodalism and to describe these policies and/or projects (See Table 3). While most states responded that policies existed or plans to implement policies existed, few states had actually implemented intermodal improvements in their state. The majority were merely "committed" to intermodalism. A few had implemented either policy or infrastructural improvements to promote intermodalism. Louisiana has completed truck / rail interchange improvements and Maine has implemented a rail access program as well as new facilities at border crossings. Iowa has started a rail loan fund program for infrastructural improvements. At a different type of interchange transfer, South Dakota has implemented a road / grain elevator interchange program, and has designated truck routes for its freight. These are concrete steps to promoting intermodal transfers in freight transportation. Other states have very generalized plans or few plans at all. Some merely state that they are committed to promoting intermodalism, while the Arizona respondents stated that they had no effort to promote intermodal activities.

Truck Restrictions

Many states place certain restrictions on trucks transporting materials in their state. These restrictions can be weight related, size related, or commodity related (See Table 4). Restrictions on transport times my also exist in certain states. Arizona, unlike many other states, has very few restrictions on hauling. Arizona has no lane restrictions, but do have hourly restrictions from 7-9AM and 4-6PM (commuter hours) in the urban areas of Phoenix and Tucson. Arizona also has speed restrictions for steep grades and overweight trucks on bridges, and prohibits hazardous cargo in a tunnel on I-10 in Phoenix.

Of the 38 survey respondents, 18 or approximately half stated that they had lane restrictions for freight haulers. Most states had lanes restricted to the two outer lanes particularly if trucks weighed more than 80,000 pounds. Montana, while not restricting trucks to designated lanes, did restrict highway usage to trucks with lower axle weights in the Spring only. However they did not specify the weight requirement. Delaware and Oklahoma also did not restrict freight haulers in general, but did restrict oversize and overweight vehicles to designated routes.

There were 19 survey respondents with hour restrictions. Most required that freight transport be performed during daylight hours particularly if oversized. Washington, Oregon, and Delaware had the added restriction of no holiday transport, and Delaware and Oregon also had no weekend transporting as did Montana and Rhode Island. Transport during peak commuter hours was restricted in Colorado, Georgia, and Oregon.

Only 12 states responded that speed restrictions existed for freight haulers. Most states either restricted haulers to a speed anywhere from 55mph to 65 mph or only restricted speeds on bridges or mountainous terrain as in Colorado. The neighboring states of California and Oregon

restricted speeds to 55 mph. Arkansas and Washington restrict speeds to 65 and 60 mph respectively. Delaware, South Dakota, and Virginia only restricted speeds on bridges or particular roadways. Montana restricts speeds based on location and time of day. It requires 65 mph limits in urban areas, 60 mph on rural highways during the day, and 55 mph on the same highways at night. Other states restricted their speeds based on weightloads. For example, Indiana restricts cargo weighing less than 26,000 pounds to 65mph, loads up to 60,000 lbs. to 60 mph, up to 80,000 lbs. or oversized loads to 45 mph, and supersized loads to 15 mph. Michigan also restricts speeds similarly from 10,000 lbs. to over 150,000 lbs. with restrictions from 55 mph to 45 mph. New Jersey on the other hand, limits speeds to 30 mph if one axle exceeds the weight limit.

All these speed restrictions are indicative of each state's location and type of industry or typical cargo within that state. Those states with speed restrictions based on weight, such as Michigan and Indiana, are areas with a lot of heavy industry and heavier cargoes. Speeds are restricted to decrease pavement damage, as well as for safety. Montana, on the other hand, is very rural and so only restricts speeds at night on rural highways.

Nineteen states surveyed stated that certain cargoes were restricted. All 19 states with cargo regulations had policies restricting the transport of hazardous materials. North Carolina and Nevada were the only states with additional restrictions regarding the transport of mobile homes or manufactured homes. North Carolina also excluded twin trailers in their state. This may also a function of each states location. Nevada has large retirement communities and is a major highway connection to Arizona, which also has large retirement communities with large markets for trailer homes. North Carolina is also on a major north-south transportation route to Florida, another large market for manufactured homes. These states have responded by restricting the flow of this particular pass through traffic.

As evidenced by the aforementioned summary of truck restrictions, Arizona has very few restrictions. This may be because most of Arizona's population is in the two metropolitan areas of Phoenix and Tucson. The remainder of Arizona is more rural. For this reason, there may be little need to restrict weights, speeds, cargoes, and hours of transport outside of its urban areas. However, Arizona also has other characteristics unique to it. Favorable weather conditions, longer distances between incorporated areas, and "a freer" regulatory philosophy in general that when compared to other states also may influence the state's lack of regulations.

TABLE 3. Intermodal Efforts.

STATE	Intermodal	Intermodal Efforts		
AR	yes	intermodal study		
AZ	no			
CA	yes	in planning - 3 documents		
CO	yes	Senate bill 37/rail	State infrastructure bank	
CT	yes	intermodal management system	port development plans	state rail plans
DE	yes	Delaware Area Regional Transit	Cape May/Lewes Ferry, cameras	Share a ride/bike to work, rail to fair
FL	yes	intermodal development program	statewide intermodal system plan	
GA				
IA	yes	eliminate access barriers	equipment, improvements	rail loan fund
IN	yes	committed		
LA	yes	intermodal priority in project selection	truck/rail efficiency improvements	
ME	yes	integrated Freight plan	new facilities, border crossings	rest areas, rail access program
MI	yes	water to truck-bulk	pipelines	Detroit Intermodal Freight Terminal
MO	yes	freight plans		
MS	yes	continuous movement permit		
MT	yes	transportation plan		
NC	no	done by NC dept. of commerce		
ND	yes	rail assistance program		
NE	no			
NH	yes	loan program for rail transfer facilities	restoring inactive rail corridors	
NJ	yes	regional planning activities	www.state.nj.us/transportation/portway support/	
NV	yes	long range transportation plan	MIS corridor studies	individual projects' process
NY	yes	Harlem River Intermodal Terminal	railroad improvements	facility & cargo access programs
OK	yes	future intermodal plan	encourage truckers to use short rails	
OR	yes	intermodal management system	"Freight moves the Oregon Economy"	2 intermodal studies
PA	yes	committed		
RI	no			
SC	yes	study on port		
SD	yes	road/grain elevator	designated truck network	
TN	no			
TX	yes	plan		
UT				
VA	no			
VT	yes	state freight study in future		
WA	yes	Eastern Washington Intermodal Study	see http://fmsib.wa.gov	
WI	yes	intermodal plan		
WY	no			

TABLE 4. Trucking Restrictions.

STATE	Lanes	Hours	Speed	Cargo
AR			rural highways -65 mph	hazardous mat. Pulaski County; & Little Rock
AZ		overweight/oversize during; commuter hours in Phoenix & Tucson	Slower speeds on steep grades; slower speed - bridges for overweight	hazardous cargo thru I10, Phoenix tunnel
CA	right hand lane	extralegal loads only	55 mph	hazardous materials
CO	left lane of I76	restricted commuter hours	mountainous terrain	hazardous material
CT	left lane prohibition	overweight/size- daylight; weekday		
DE	os/ow vehicles; toll plazas; during construction	not on weekends/holidays; daylight only	superloads on bridges	
FL	90000 lbs.- interstates intl. Cargo; 80000 lbs.- all other arterials			
GA	left lane restricted; cannot enter Atlanta without delivery	daylight; no peak commuter hours		hazardous materials
IA				
IN		overweight/oversize-830-1530	<26000lbs. - 65mph; 26000-60000 lbs. - 60mph; >80000 lbs./oversized - 45mph; supersize - 15mph	hazardous materials
LA		in metro areas only		hazardous materials/explosives
ME		daylight for overweight		
MI	right two lanes->10000 lbs.		>10000 lbs.-55 mph on freeways; <150000 lbs. -55 mph on all roads; >150000 lbs. -45 mph on all roads	explosives in Detroit; flammable liquids in Detroit
MO				
MS		daylight		
MT	in spring, lower axle weights only	oversize-no weekends	65 mph- interstate, urban areas; 60 mph day- US93 & other highways; 55 mph night- US93 & other highways	hazardous materials
NC	outer 2 lanes			limit twin trailers; limit mobile homes
ND				hazardous waste
NE	only by weight for bridges	daylight		
NH				radioactive waste
NJ	>10000 lbs. left lane restricted		1 axle exceeds limit - <=30mph	radioactive mat. route controls
NV				hazardous materials; oversize-manufactured homes
NY	third and additional lanes restricted			explosives in NYC tunnels
OK	extra heavy/wide identify routes			
OR	80000 lbs. max.; federal bridge formula	daylight, no weekends, holiday; commuter hours noninterstate	55 mph	hazardous material
PA	right lane			hazardous materials
RI	2 right hand lanes	oversize/weight -no weekend; time of day		
SC				
SD			spring- certain roadways	
TN				
TX		oversize- daylight; cylindrical bales-daylight		hazardous materials
UT	left lane->3 lanes exist & >12000 lbs.	daylight->10'w, 92'l, 14'h		hazardous materials
VA		overwidth- night moves	overweight - on bridges/culverts	
VT				
WA	left restricted-commercial trucks	holidays	60 mph	flammable materials-tunnels I90
WI		oversize		
WY	2 outside lanes only	daylight		

Enforcement of Regulations

In the final section regarding regulation enforcement and fee collection, the method cited most often in the survey was mobile units (see Table 5). Fixed ports of entry were also widely used. Surprisingly, weigh stations were not utilized in many states as fee collection sites. With the exception of California, those states that did utilize weigh stations did not collect fees at fixed ports of entry. Only Arizona collects fees utilizing fixed ports of entry and mobile units as well as special interdepartmental task forces. Three states, Nebraska, Tennessee, and Washington, distinguished between their use of portable scales and mobile units. In these states portable scales and mobile units may refer to different types of technologies even though both are mobile. The same may also be said for ports of entry and weigh stations. A weigh station does not necessarily have to be at a port of entry. In order to enforce weight restrictions, it may be more efficient to have some weigh stations dispersed throughout a state in order to enforce intrastate traffic or that traffic that transports only within that state. Several states also utilized weigh-in-motion technologies to collect fees.

In order to make collections quicker or easier, respondents were asked to describe methods to expedite the collection process. The responses varied widely from the technological such as weigh-in-motion devices, prepasses, the internet, automatic vehicle identification to the not so technological like one-stop-shop centers. Many states have implemented web page payment systems, accept credit cards, and Commercial Vehicle Information systems Networks to electronically track permits and identification with neighboring states. Georgia, Iowa, Michigan, Oregon, Texas, Virginia, and Wyoming are the most technologically advanced in their regulation enforcement. However this does not appear to follow any pattern; they just are the first states to utilize the internet in their enforcement. A second tier of technologically oriented states includes California, Colorado, Indiana, Mississippi, Nevada, Utah, Vermont, Washington and Wisconsin. This second tier group utilizes such items as credit card payment, automatic vehicle identification, and prepass systems, but has not progressed to the internet. The remaining states either have plans for the aforementioned methods or simply us the court system, the state patrol, and payment with registration through the department of transportation. The states in this third category include: Arkansas, Connecticut, Delaware, Florida, Louisiana, Maine, Missouri, Montana, North Carolina, North Dakota, Nebraska, New Hampshire, New Jersey, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, and Tennessee. A few states in this third tier such as Louisiana, Maine, Delaware and Florida have implemented one stop shopping to expedite the process. These third tier states are primarily smaller states with smaller populations and so may have limited resources to implement such collection methods.

Arizona, in comparison with other states, falls in the second tier group. Arizona utilizes electronic issuing systems, credit card payments, and escrow accounts in expediting the permit and regulation enforcement process. However unlike other states in this group they do not use automatic vehicle identification systems or prepass systems. While ADOT has a web page, it is not at this time used to enforce regulations, obtain permits or assist in expediting the permit process in any way.

TABLE 5. Methods and Locations of Fee Collections and Regulatory Enforcement.

State	Mobile Units	Fixed ports of entry	Weigh Stations	Weigh in Motion	Portable Scales
AR	*	*			
AZ	*	*			
CA	*	*	*		
CO	*	*		*	
CT					
DE			*		
FL	*		*		
GA	*		*		
IA			*	*	
IN	*	*	*		
LA	*	*			
ME	*		*		
MI	*		*	*	
MO	*		*		
MS	*	*			
MT	*				
NC	*		*		
ND	*	*			
NE					*
NH	*	*			
NJ					
NV	*	*			
NY	*	*			
OK	*	*			
OR		*			
PA	*				
RI	*				
SC		*			
SD	*	*		*	
TN	*				*
TX	*	*			
UT	*	*		*	
VA	*		*		
VT	*		*		
WA	*	*		*	*
WI	*	*		*	
WY	*	*			

* Note: Only states responding to the survey are shown.

Trucking Firms' Survey Results

The mail-in survey was sent to over 250 freight hauling companies and had a 12% response rate. While a normal response rate for such a survey, within that 12%, a number of freight haulers (10 respondents) answered only questions in the background section. Of these, six freight haulers stated that they had no problems regulatory, roadway or otherwise. Only 20 of 30 respondents answered the survey's remaining sections. This is believed to be a result of the position of the respondent actually filling out the survey – either the president/owner or secretary. The president of a company may not actually be out on the roadways and therefore may not be aware of particular roadway or regulatory problems like their drivers would. A random sample of the actual truckers taken at various truck stops might shed much different results. See Appendix D for Carrier Survey detail.

The trucking companies' lack of detailed response may indicate satisfaction with Arizona State Highway service, ignorance of the existing problems, or apathy towards this investigation or improvement of the system. Therefore, the responses, relayed in the following sections, should be viewed as anecdotal and only giving one an indication of possible problem areas. These sections are -- 1) Carrier Background & Sample Characteristics, 2) Regulatory Problems, 3) Roadway Problems, 4) Intermodalism, and 5) Other Needs and ADOT Improvements.

Carrier Background & Sample Characteristics

The survey sample while representative of the larger population and diverse in the business handled, garnered a response lacking in detail with few problems mentioned. While over half of the survey respondents utilize standard vans, double trailers, refrigerated units and flatbeds are also widely used. Grain trailers, curtain vans, and transfer end dumps were also truck types cited by respondents.

Haul types also varied among respondents. Long distance hauls were cited as frequently as short distance hauls and many respondents do both. The amount of urban only haulers while small, corresponds with intrastate haulers or those haulers operating only in Arizona. The majority of respondents, 77%, stated their routes had either an origin or destination within Arizona. Only 23% of the freight haulers operated passthrough traffic. A previous ADOT sponsored origin and destination survey found that 58% of commercial drivers indicated in-state destinations and 42% indicated out-of-state destinations (Behaviour Research Center, 2000). This survey however had an extremely small commercial sample size of fourteen (14) companies. This statistic also refers to destination only whereas in this report's survey includes either an origin or a destination.

Regulatory Problems

Carriers cited few regulatory problems overall. Those mentioned, primarily were a result of construction or congestion. Several locations were cited for having lane restrictions resulting from construction. I-93 may be a continuing problem due to its already overcapacitated state. However with that exception in mind, construction and congestion along other routes may be the result of seasonal or regular roadway maintenance and not a continuing problem. Hour restrictions were also cited as bothersome as freight haulers are restricted to one lane along I-17

and I-10. But it is not known from their responses when or why these hourly restrictions occur on these routes.

Inspection stops were also considered problematic due to restricted hours of operation for portable inspection stops. However it is not clear if it is problematic because the inspection stops are portable and therefore the hauler does not know when or where it will be open. Since the nature of portable inspection stops is to enforce state regulations, it is not recommended to "fix" this problem for freight haulers.

One hauler in particular stated the need for a program similar to California's inspection program. If a truck passed inspection, they would be issued a compliance sticker so that vehicles are not stopped three times a day. This would result in less time and revenue lost.

Ports of entry were mentioned several times by respondents as problematic. Several ports of entry were entered for a variety of reasons including congestion, one booth operating at a time or no one operating any booth or checking scales for the majority (85%) of the time. One carrier stated that this results in delays up to 15 minutes. Haulers also stated that port officers did not know the regulations well, particularly exempt products. Complaints regarding inspection of domestic products at ports of entry were also issued. Haulers felt that this was repetitive and a loss of time. The design of ports of entry were also at issue with carriers. One carrier stated that it is difficult for extra long trucks to maneuver as a result of the design. Interestingly, international ports of entry were not cited as problematic.

While some of the regulatory problems cited by carriers may be difficult for ADOT to ammend due to the nature of road repair or certain types of regulation enforcement, poorly manned and designed ports of entry are issues that can be resolved with additional staff and infrastructural improvements.

Roadway Problems

Roadway problems, on the other hand, were cited more frequently. Carriers named several locations and routes with poor pavement conditions and referred to rutted lanes, rough bridges and railroad crossings. However, different routes and locations were overcapacitated according to the freight haulers. It is unclear from the survey whether the road segments with poor pavement were neglected or the result of heavy traffic.

Capacity was also mentioned as a safety concern along US 93 and I-8, but other overcapacitated routes were not serious safety hazards. The I-10 tunnel in downtown Phoenix was also perceived to be hazardous due to traffic switching lanes and inadequate lighting in the tunnel. Another issue that may be a safety concern is trucks stopping for ramp metering traffic lights before merging into traffic. This traffic management device may be hazardous for the freight hauler to come to a complete stop and move forward again to try to merge into 65 mph traffic on the freeway.

Signage issues presented by the survey were also related to safety. One carrier felt that signage is necessary on all on ramps along I-10 between 99th Ave. and I-17 reminding motorists

to merge every other vehicle. Related to the aforementioned inadequate lighting in the tunnel, another carrier suggested signage requiring motorists to use headlights while in the tunnel.

Even the problems mentioned under the turnouts and roadside amenities category could be related to safety. Carriers stated that there are not enough turnouts or other places where truckers may rest along Arizona's highways, particularly rural highways. Closed rest areas were also seen to be a hazard to truckers, as were inoperable phones at the rest areas that are open. Should a hauler have a problem at the rest area, he is unable to call from the rest area utilizing the current phone system. Carriers stated that at most rest areas telephones are inoperable.

These roadway problems are correctable problems. With better maintenance of these particular road segments, poor pavement condition can be reduced. Signage can be placed on ramps and in the I-10 tunnel to improve safety. Overcapacitated routes, given time and resources, can be expanded with additional lanes.

Intermodalism

Intermodalism, while of national concern, does not appear to be a concern of Arizona freight hauling. Only 37% of the respondents do some sort of intermodal transfers. Of those the majority make transfers to rail and secondarily make transfers to air. Two carriers in the survey makes transfers to water or shipping modes of traffic, but do so in California which is outside of Arizona.

Complaints regarding intermodal transfers were few. Respondents cited lengthiness of loading/unloading times as well as inadequate operating hours on the part of Union Pacific. It was mentioned that Union Pacific closes its operations too early and is not open for business on weekends, while trucking occurs on a daily basis. While these are valid complaints, little can be done by the Arizona Department of Transportation or the state to improve these specific problems. If more carriers that performed intermodal transfers were surveyed maybe other issues would present themselves relating to ease of intermodal transfers and infrastructure.

ADOT Improvements

In the final portion of the survey, carriers expressed other needs and suggested improvements in Arizona State highway service and regulations. Similar to previous issues presented, many carriers named increased capacity and increased number of turnouts, and a quick completion of the 101 loop. However other needs or improvements regarding Arizona regulations were also expressed. Some carriers complained that the licensing program in Arizona is not competitive with other states resulting in some companies licensing equipment in other states to avoid costs during certain periods. Another stated that out of state haulers undercut Arizona haulers rates. This carrier suggested a standardized freight rate structure be created and enforced by ADOT. Ports were also mentioned needing much improvement regarding efficiency and manpower. One carrier suggested ADOT work more closely with DPS to ensure improvements are made. More law enforcement was also presented as a need on several highways particularly on I-10 and I-8. As major freight corridors with few urbanized areas less law enforcement, it is likely that more vehicles would not abide by state regulations or even have faulty equipment. More patrols may reduce the amount of infractions over a long period of time.

While the aforementioned carriers presented new issues not previously addressed in the survey or reiterated important problems, there were three carriers that expressed the opinion that ADOT's performance is excellent overall and would not make any changes in their service at all. One in particular stated that when improvements were made, conditions worsened. This particular respondent did not give any details on the situation.

GIS Analysis

This section provides a spatial analysis of the commercial freight hauler traffic data and roadway design. The data have been mapped in order to visualize where the major problem areas are in the State of Arizona.

In Figure 2, average annualized daily traffic for all traffic is highest in the Phoenix urban areas. With the exception of Interstate 10 and 17, the remainder of the state has low traffic volumes overall, from 0-17,000 vehicles per day. These are U.S. highways and Arizona's state highways. These routes are mainly two-lane highways (See Figure 5). This lends credence to the argument that Arizona is primarily rural in nature, particularly in its transportation network.

Figure 3 also shows that the average daily commercial (i.e. truck) traffic is highest in Phoenix's urbanized area and interstates. While the volume of traffic is much smaller, the pattern of traffic remains the same. Arizona's state highways have a low volume of commercial traffic (0 - 4,000) in comparison to other segments like I-10 and I-17. However, from the percentage of commercial traffic by highway segment, many of these same two lane routes are major commercial routes. These major non-interstate commercial routes include: US 93, US 60 between Phoenix & Wickenberg, AZ, US 89 by Page, AZ, US 180 by Eagar, AZ, State Route 85 between I-10 and I-8, State Route 377, State Route 277, and State Route 66. All of these routes have only two throughlanes, and yet 22 to 41% of the daily traffic volumes on these segments are commercial truck traffic. Therefore these routes have the same percentage of commercial traffic as the interstate highways in Arizona.

The volume/service flow ratio is a reflection of the capacity per segment. The volume/service flow ratio is a computed value reflecting peak hour congestion for a sample section. (See Appendices E and F for definitions and procedures for data collection). Many of the aforementioned non-interstate routes have high existing volume/service flow ratios, as much as 1.19 on certain segments (See Figure 6 and Table 6). This confirms many of the complaints cited by the trucking companies that participated in the survey particularly those that complained about capacity on US 93. As seen in Figure 6, the major interstates, I-10, I-40, and I-17 have a high volume/service flow ratio particularly I-10 between Phoenix and Tucson. These non - interstate and interstate routes are high priority routes due to the volume of commercial traffic and for severely exceeding the capacity of the route.

Figure 7 shows how much each route with a volume / service ratio exceeding 0.3 can be widened. The interstates 10, 17, and 40 all have high volume / service ratios and can all be widened by up to three or more lanes. The non-interstate high priority routes vary by segment in how many additional lanes they can accommodate. See Table 6 for detail.

Figure 2.
Average Daily Volumes - All Traffic, 1998

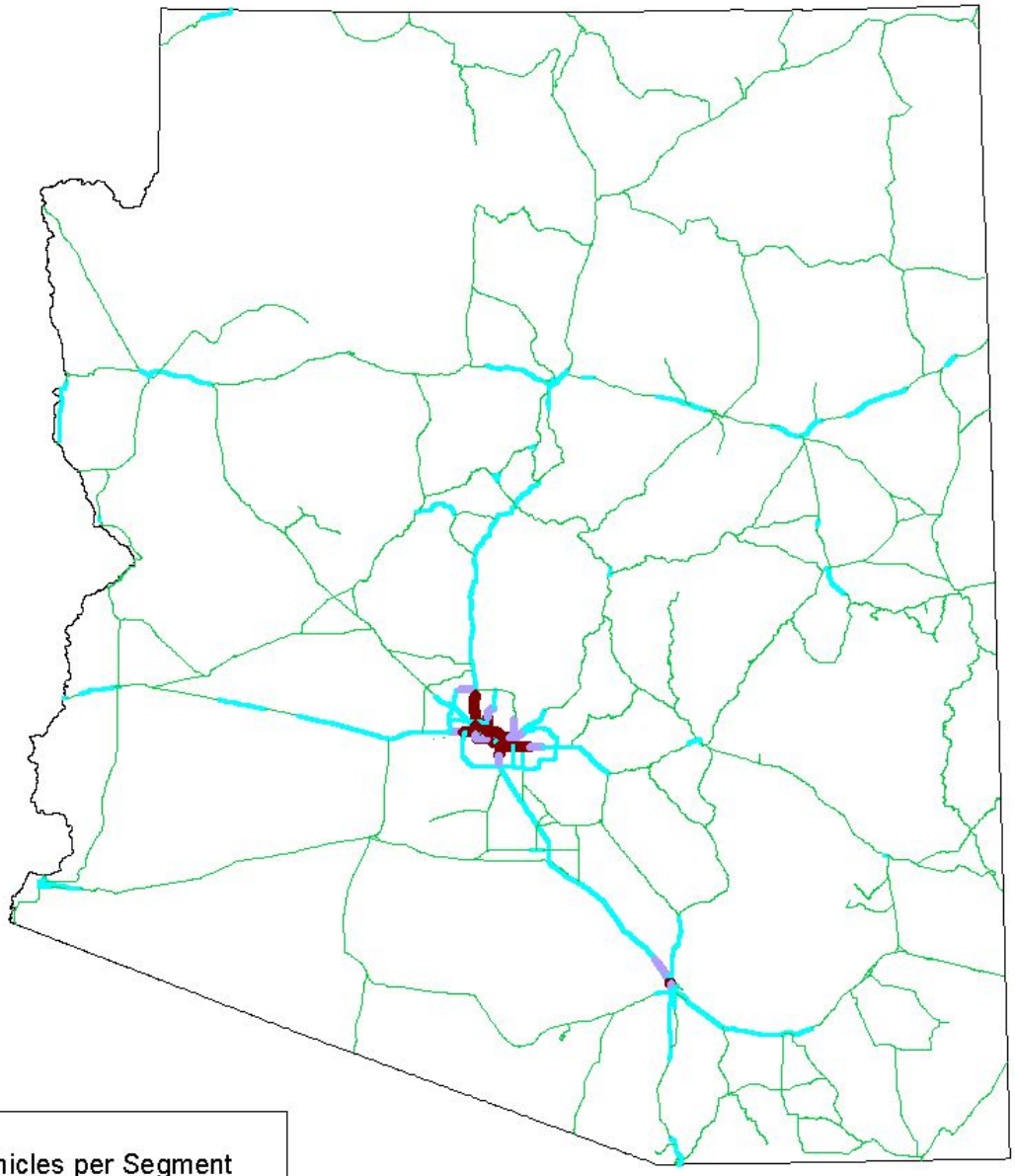


Figure 3.
Average Daily Commercial Traffic Volumes, 1998

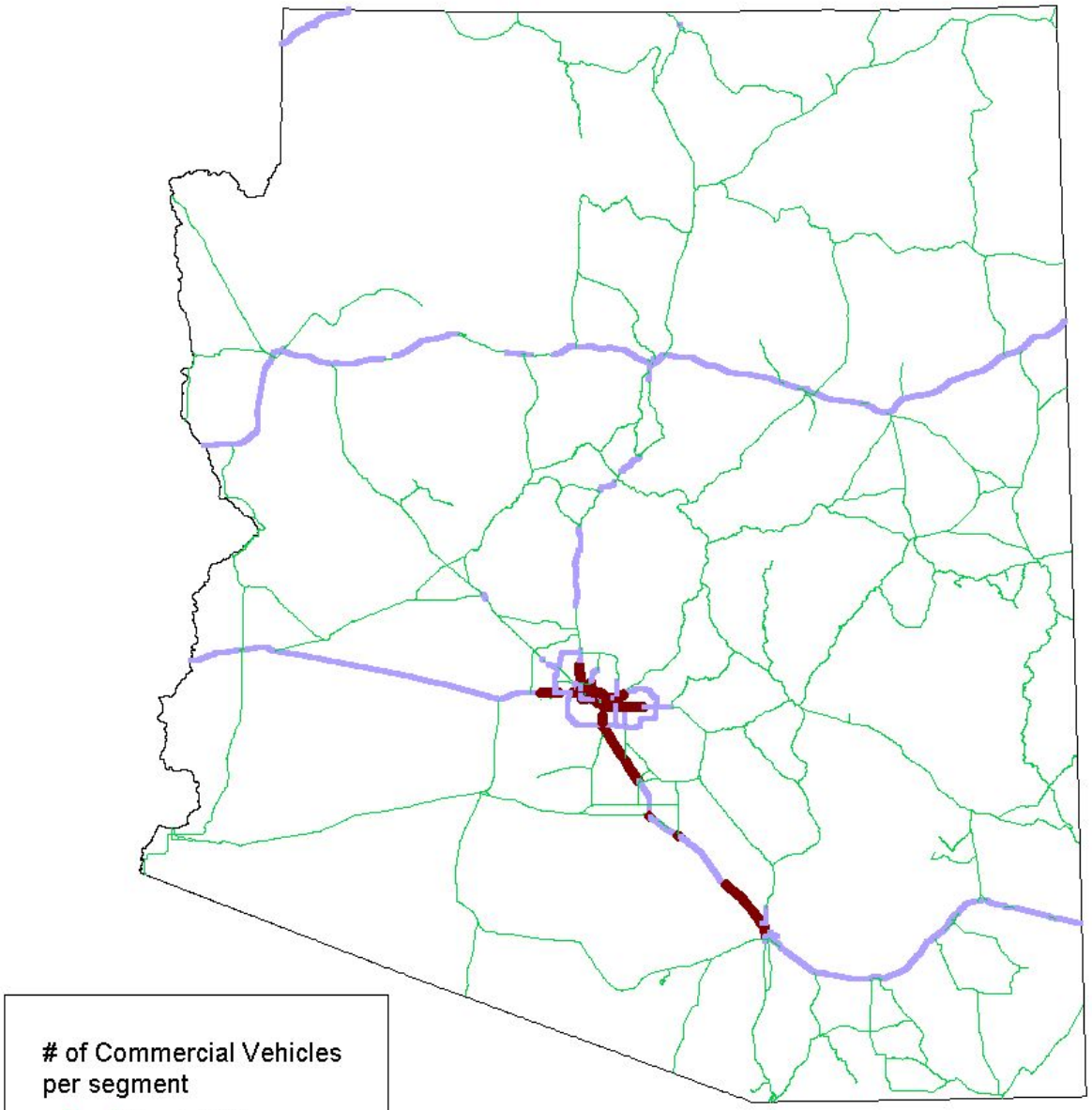


Figure 4.
Percent of Commercial Traffic, 1998

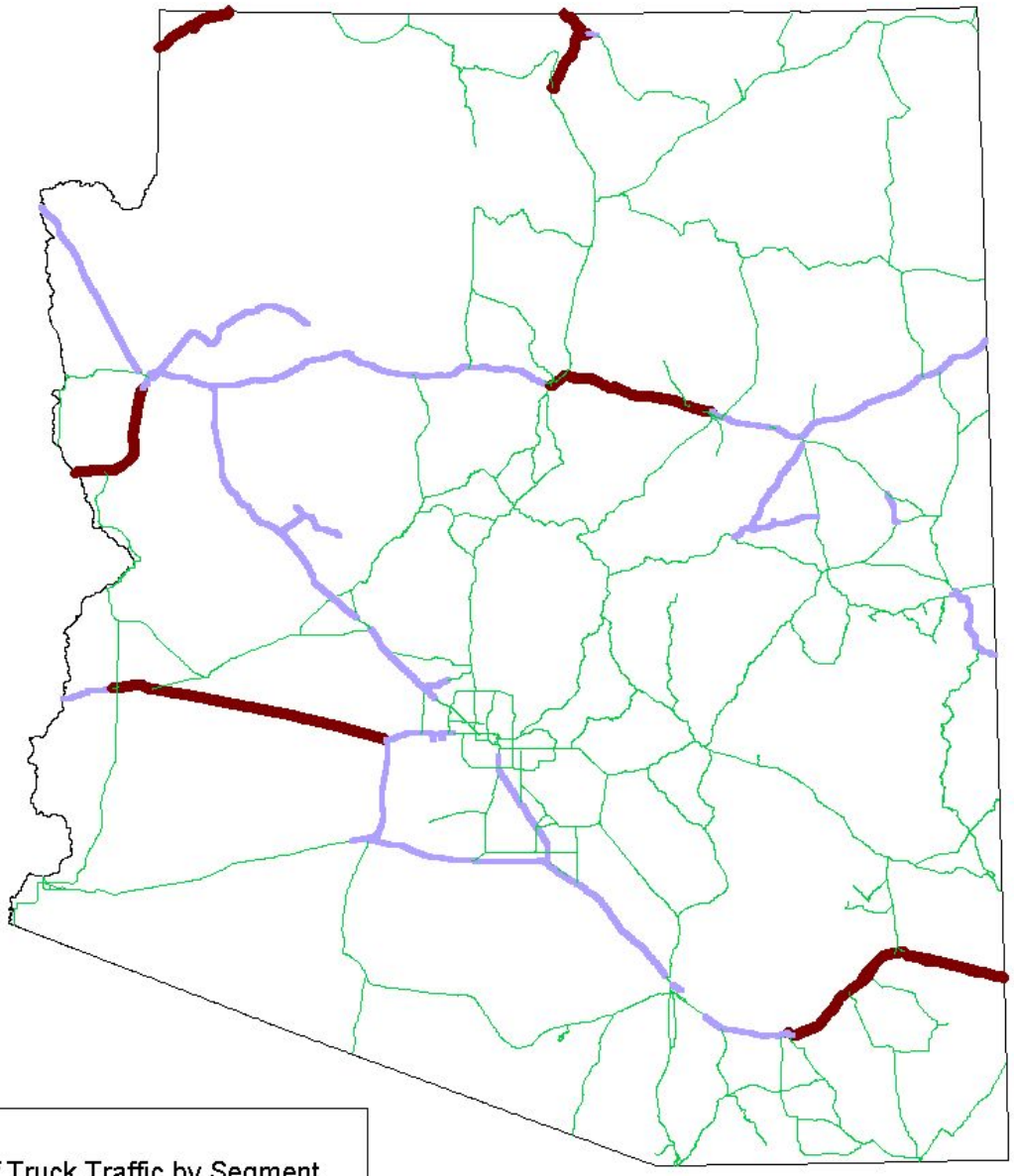


Figure 5.
Number of Thrulanes

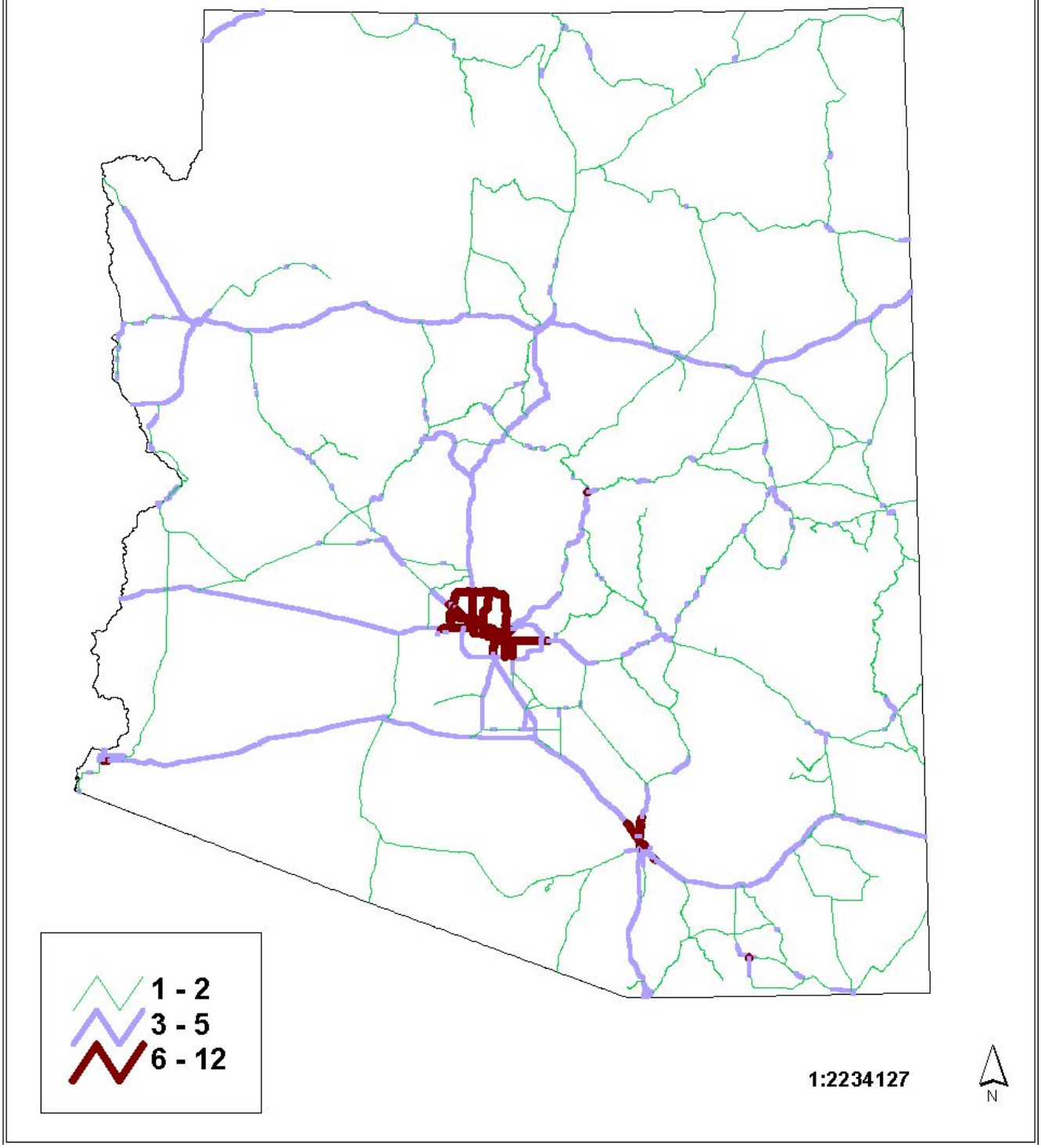


Figure 6.
Volume/Service Flow Ratio, 1998

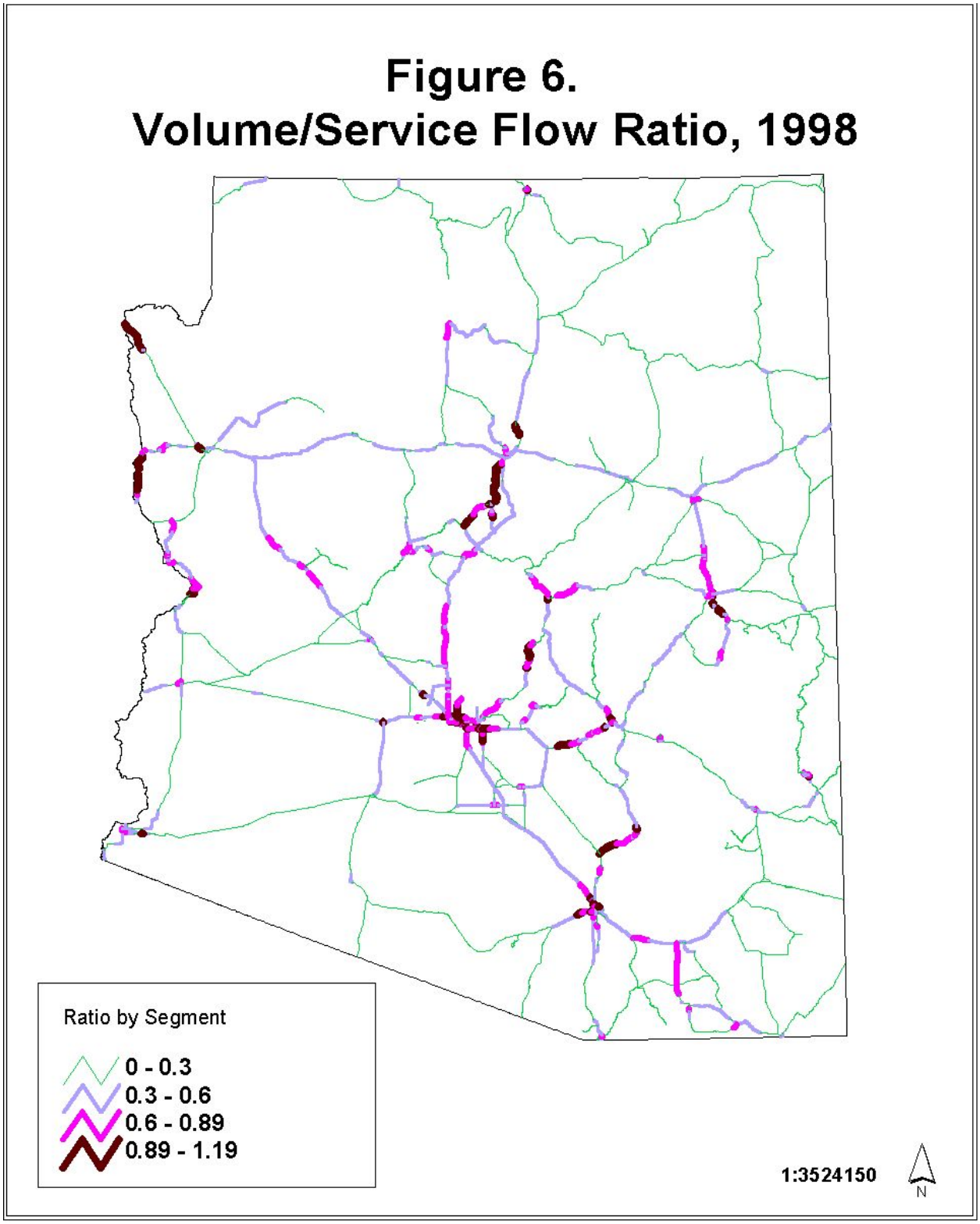
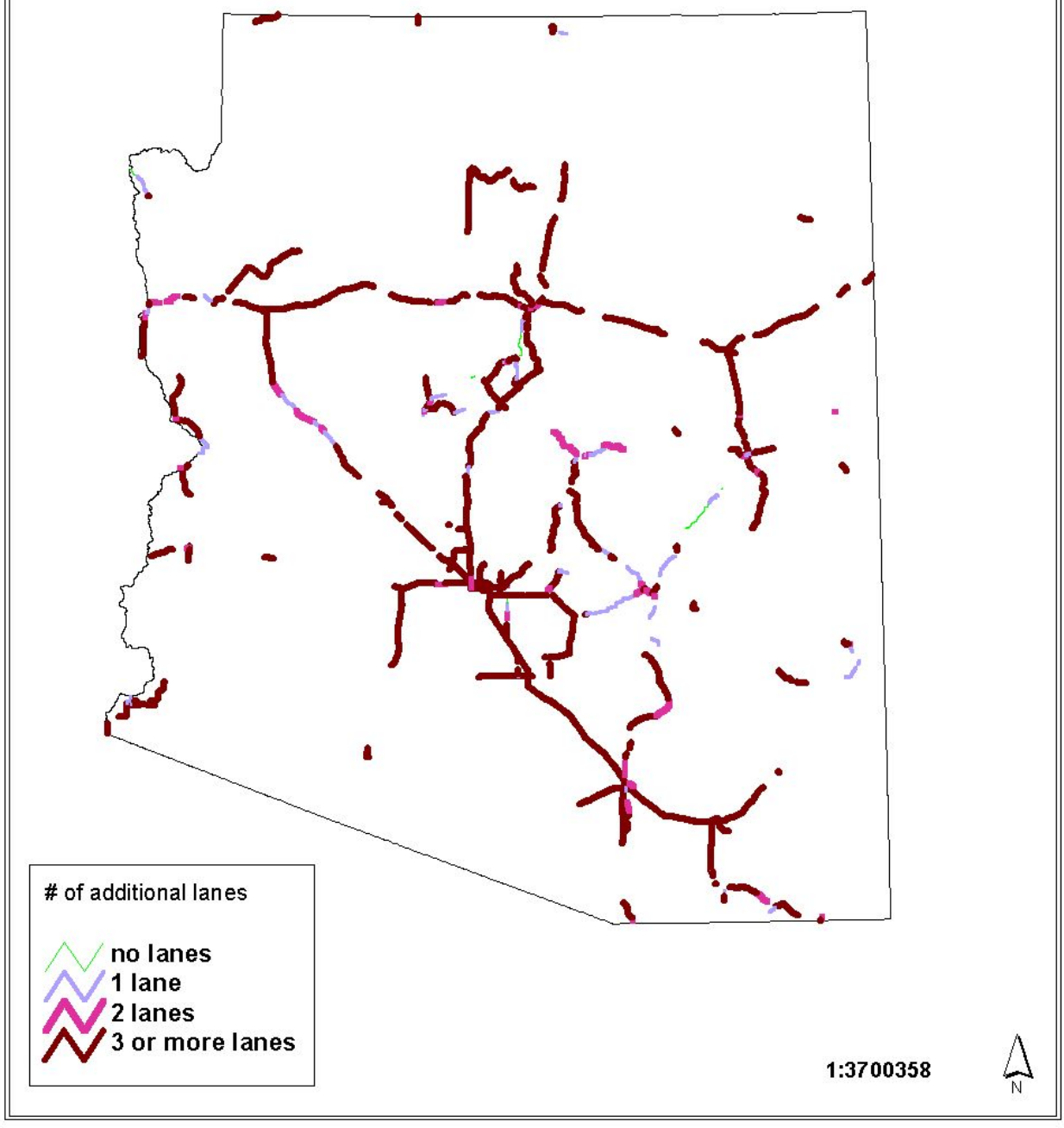


Figure 7.
Segments with high Volume/Service ratios that can be Widened



These routes while major commercial routes in Arizona, are not the only non-interstate routes in need of attention. Other non-interstate routes have extremely high volume / service ratios. Figure 6 shows that the following non-interstate routes in addition to those previously mentioned are severely over capacity. These routes include: State Route 77, State Route 66, State Route 260 by Payson, State Route 188, State Route 90, State Route 87 by Payson, State Route 89 between Sedona and Flagstaff, and US 60 east of Phoenix. These routes are medium priority routes.

The remaining routes in the state do not have high volume/service ratios and are not major commercial routes. Commercial traffic is only 2-21% of all traffic on these routes. These are low priority routes.

In Table 6 the aforementioned high and medium priority non-interstate routes are identified with their current amount of throughlanes, volume/service flow ratio and the number of additional lanes that could be built on each route. Many of the high priority, non-interstate route segments can be widened by more than 3 lanes, as can the medium priority route segments. US 93 varies in how many additional lanes can be added. In the area immediately surrounding Wickenberg, Arizona, the number of additional lanes is zero. While it may be possible to physically widen US 93 around these communities, again it may not be financially feasible. State Route 89 between Sedona and Flagstaff, and US 60 east of Phoenix have very high volume/service flow ratios. However, SR 89A cannot be widened at all and US 60 can only be widened by 1 lane. State Route 89A is impossible to widen due to the terrain, and US 60 east of the Phoenix metro area, it may be financially and environmentally infeasible as well. Therefore, for these two routes, other means of service improvement will have to be investigated.

Table 6. Major Non – Interstate Commercial Routes

Major Route	# of lanes	Volume/Service Flow Ratio	# of additional lanes
HIGH PRIORITY			
US 93	2	0.3-0.89, varies	1 to 3, varies
US 60 Between Phoenix & Wickenberg	2	0.3-0.89, varies	3 or more
US 89 by Page	2	0.6-0.89 in Page, AZ	1 to 3, varies
State Route 85 between I-10 & I-8	2	0.3-0.6	3 or more
MEDIUM PRIORITY			
State Route 77	2	0.3-1.19, varies	3 or more
State Route 66	2	0.3-0.6	3 or more
State Route 260, by Payson	2	0.3-0.89	1 to 2
State Route 87, by Payson	3 to 5	0.6-0.89	2 to 3, varies
State Route 188	2	0.3-0.6	3 or more
State Route 90	2	0.3-0.89	3 or more
State Route 89 between Sedona & Flagstaff	2	0.89-1.19	0
US 60 East of Phoenix	2 to 5	0.3-1.19, varies	0 to 1

CONCLUSIONS

This study incorporates freight hauling company concerns and perceptions in an investigation of Arizona State Highway service as well as examine what policies other states have implemented to identify options that may mitigate trucking company concerns. These concerns and populations were left out of previous reports (Matranga & Semmens, 2000; Hernandez, 1997; ADOT, 1998; Behavior Research Center, 2000; Radwan, *et al*, 1987). This study found that different state agencies have very different restrictions on trucking as well as various means of collection and reinforcement. But it also found that while other states may be moving onto other concerns such as improving efficiency of highway service, Arizona may not only need to improve highway service but also expand capacity and safety. Both of which are traditional spending priorities.

Arizona collects vehicle classification data and annual traffic volumes, utilizing the same methods most cited by other states like axle counter and weigh-in-motion technologies. However unlike other states, Arizona does not use these technologies for regulation enforcement. Very few states had plans to promote intermodal activities. Arizona has no current specific effort to promote intermodal activities.

Freight hauling restrictions can impact transit time. Such restrictions will reduce the level of service of the highway to the freight carrier. However, Arizona, unlike many other states, has very few restrictions on hauling. This may be because most of Arizona's population is in the two metropolitan areas of Phoenix and Tucson. Arizona has no lane restrictions, but do have hourly restrictions from 7-9AM and 4-6PM (commuter hours) in the urban areas of Phoenix and Tucson. Arizona also has speed restrictions for steep grades and overweight trucks on bridges, and prohibits hazardous cargo in a tunnel on I-10 in Phoenix. In the trucking survey, carriers cited few regulatory problems overall. Those mentioned, primarily were a result of construction or congestion. Therefore regulatory hauling restrictions do not appear to adversely impact level of service. Arizona's rural nature was also found to be influential on the lack of regulatory measures. Favorable weather conditions, longer distances between incorporated areas, and "a freer" regulatory philosophy in general also may influence the state's lack of regulations.

With regard to regulation enforcement, the preferred method of fee collection was mobile units. Fixed ports of entry were also widely used. With the exception of California, those states that did utilize weigh stations did not collect fees at fixed ports of entry. Only Arizona collects fees utilizing fixed ports of entry and mobile units as well as special interdepartmental task forces. Several states also utilized weigh in motion technologies to collect fees. Arizona, like other states, has weigh stations, but they also have agricultural inspection stations and border patrol inspection stations. Thus creating more opportunities for delays and congestion at various stopping points in the system.

The major ports of entry into Arizona via other U.S. states were found to be problematic—in particular, Ehrenberg, Yuma, Parker, and the New Mexico – Arizona port of entry. Problems found with ports of entry included congestion, poor staffing, delays up to 15 minutes, and poor port design.

In Arizona, during the five years prior to NAFTA, exports to Mexico increased 153% (Ammirati, 1999). Since the inception of NAFTA, Arizona exports have increased an additional 83% (Ammirati, 1999). However, trucking survey respondents did not cite international ports of entry as problematic. According to other studies, international port design and cross-border traffic are serious issues and something Arizona has not paid much attention to in the past (Dye et al, 1999; Liu and Shinbein 1999; U.S. GAO, 1997; McCray and Harrison 1999; Haines, 1997; Canamex, 1999). From this study it is unclear how many companies do perform cross-border traffic. Therefore the issue may not be a concern for this particular trucking sample.

NAFTA has great implications for freight corridors from Mexico to Canada. As previously mentioned, McCray and Harrison (1999), showed that several corridors are apparent when trade flow routes from Mexico and Canada are combined. Canamex, Arizona's North American trade route, extends from Nogales, Arizona and continues through Nevada, Utah, Idaho, and Montana. Canamex is currently involved in infrastructural improvement plans to create an I-19 and I-10 bypass, expand intermodal and warehousing facilities, increase capacity along US 93 as well as a new rail port of entry in Naco, Arizona (Canamex, 1999). Future ADOT research should focus on the needs of the commercial cross-border traffic user group.

Roadway Problems found in this study included poor pavements, routes with high/volume service ratios, congestion along specific segments particularly in urban areas, and decreased safety along specific segments due to a lack of signage, capacity, turnouts, and poorly equipped rest areas. Arizona's participation in a pavement demonstration project may in future lead to better pavements. However, Arizona's allowance of longer combination trucks increases wear on pavements, and reduces safety (U.S. GAO, 1993). The majority of problems occurred in the highly trafficked urbanized areas of Phoenix, and the commercial routes like I-10 and US 93.

This study also found that certain non-interstate routes are important commercial traffic routes and have volume / service ratios as high as 1.19. This is in agreement with many of the complaints cited by the trucking companies that participated in the survey. These roadways include: US 93, US 60 Between Phoenix & Wickenberg, AZ, US 89 by Page, AZ, State Route 85 between I-10 and I-8. All of these routes have only two throughlanes, and yet 22 to 41% of the daily traffic volumes on these segments are commercial truck traffic. This lends credence to the argument that Arizona is primarily rural in nature, particularly in its transportation network. These routes as well as the major interstates, I-10, I-17, and I-40 are slated high priority roadways for capacity improvements. Medium priority routes include: State Route 77, State Route 66, State Route 260 by Payson, State Route 188, State Route 90, State Route 87 by Payson, State Route 89 between Sedona and Flagstaff, and US 60 east of Phoenix. The remaining low priority routes have volume/service ratios from only 0 to 0.3 and are not major commercial routes.

This research also found that state agencies' methods to expedite the collection process can be divided into three categories. The first tier states have implemented web page payment systems, accept credit cards, and use Commercial Vehicle Information Systems Networks to electronically track permits and identification with neighboring states. This second tier group

utilizes such items as credit card payment, automatic vehicle identification, and prepass systems, but has not progressed to the internet. The remaining states either have plans for the aforementioned methods or simply use the court system, the state patrol, and payment with registration through the department of transportation. The third tier states are primarily states with smaller populations and so may have limited resources to implement such collection methods.

Arizona, like the second tier group, utilizes electronic issuing systems, credit card payments, and escrow accounts in expediting the permit and regulation enforcement process. However unlike other states in this group they do not use automatic vehicle identification systems or prepass systems. While ADOT has a web page, it is not at this time used to enforce regulations, obtain permits or assist in expediting the permit process in any way. Arizona obviously still has a long way to go in the electronic age. Many trucking companies have access to the internet and email as evidenced by the trucking survey. To save the companies further time and money by further utilizing the web to expedite regulation processes would go along way in serving companies needs.

The transportation industry has changed as a result of a highly competitive global market and thus affected Arizona as well. International trade and transportation agreements have helped global commerce flourish, but today's market depends upon efficient logistics, customer service, and just-in-time inventory systems. Business wants high-quality transportation service that is speedy, flexible, competitively responsive and low cost. Optimal efficiency is the goal of the future rather than constructing new roadways (Williams and Hoel, 1998). Planning models and economic equilibrium models in future will be used to assess highway service, plan for freight efficiency, and result in reducing transport operation costs particularly those associated with congestion (Williams and Hoel, 1998). Methods such as congestion pricing, increasing road capacity, use of electronic data interchange, automated international border clearances and improving intermodal efficiency are the latest developments of transportation service improvement (Golob and Regan, 1999). However, from this research and the relative newness of Arizona's highway system, Arizona not only needs to increase efficiency by redesigning ports of entry, reducing congestion and traffic management, but it also needs to increase capacity along particular road segments such as U.S. 93 and certain parts of I-10.

Clearly Arizona's location as a border state as well as its recent population increases resulting in a relatively new interstate system make its situation and needs unique. Investment in overcapacitated routes may take priority, but should be accomplished in conjunction with meeting other needs such as the North-South Canamex trade route. With increased trade for Arizona, commercial traffic will increase, magnifying the need to accomplish both priorities—traditional capacity and safety measures and efficiency measures.

REFERENCES

Ammirati, Sean. 1999. *The Effect of NAFTA on Arizona Industry*. The Goldwater Institute. August.

Arizona Department of Transportation. 1998. *1998 Status and Condition of the Arizona Highway System.* Arizona Department of Transportation, http://map.azfms.com/98statcond/index.html.

Behavior Research Center. 2000. *Arizona Highway User Origin and Destination Survey*. Arizona Department of Transportation.

Benekohal, Rahim F., Yoassry M. El-Zohairy, Earl Forrler, and Murat F. Aycin. 1999. Truck Delay And Traffic Conflicts Around Weigh Stations: A Case Study In Illinois, Submitted for presentation/publication at the Transportation Research Board 78th Annual Meeting, Washington, D.C.

Bochner, Brian, Lisa Dye, and Robert Eckols. 1999. Optimization of Truck Movement Through U.S. - Mexican Commercial Border Crossings, Submitted for presentation/publication at the Transportation Research Board 78th Annual Meeting, Washington, D.C.

Clarke, David B. Arun Chatterjee, Stephen M. Rutner, and Harry L. Sink. 1996. Intermodal Freight Transportation and Highway Safety. *Transportation Quarterly*. v. 50, n. 2, 97-110.

Curiagin, Wiley. 1997. Evasion of Weight Enforcement Stations by Trucks, *Transportation Research Record 1570,* Transportation Research Board.

Department of Transportation. 1995. *Intermodal Freight Transportation: Overview of Impediments and Data Sources for Intermodal Transportation Planning*, v. 1 & 2, Reports #DOT-T-96-04 & DOT-T-96-05, December.

Dye, Lisa, Robert Eckols, Brian Bochner. 1999. Operational Characteristics Of Commercial Border Stations Along The U.S.-Mexico Border, Submitted for presentation/publication at the Transportation Research Board 78th Annual Meeting, Washington, D.C.

Fawcett, Stanley E. & David B. Vellenga. 1992. Transportation Characteristics and Performance in Maquiladora Operations, *Transportation Journal*, summer, p. 5-16.

Federal Highway Administration. 1999. *Highway Performance Monitoring System Field Manual*, United States Department of Transportation, http://www.fhwa.dot.gov/ohim/hpmspage.htm.

Golob, Thomas F. & Amelia C. Regan. 1999. Freight Industry Attitudes Towards Policies To Reduce Congestion, Paper Presentation. Transportation Research Board 78th Annual Meeting, Washington, D.C.

Haines, Renee. 1997. Charting a new Route for Commerce—Interstate 69, *Site Selection*, Feb./March, p.97-108.

Harrison, R., L.A. Sanchez-Ruiz and C.E. Lee. 1998. Truck traffic Crossing Texas-Mexico Border, *Pavement Management and Monitoring of Traffic and Pavements*, v. 1643, 136-142.

Hernandez, Bruce. 1997. *Arizona Quality Initiative Survey of Highway Users and Community Leaders*, Arizona Department of Transportation.

Hewitt, Julie, Jerry Stephens, Kristen Smith, and Nate Menuez. 1998. Infrastructure and Economic Impacts of Changes in Truck Weight Regulations in Montana, Paper Presentation. Transportation Research Board 78th Annual Meeting, Washington, D.C.

Horowitz, Rose A.. 1990. Maquiladoras Welcome Trade Accord; Predict Lower Traffic Costs in Mexico, *Traffic World*, July 23, p. 54-57.

Jessup, Eric, & Kenneth Casavant. 1996. *Evaluation of Violation and Capture of Overweight Trucks*, Washington State Transportation Center, Washington State University. July.

Kerali, Henry R. and Vesa Mannisto. 1999. Prioritisation Methods for Strategic Planning and Road Work Programming in HDM-4, Paper Prepared for the Transportation Research Board 78th Annual Meeting, Washington, D.C.

Kuby, Michael, & Neil Reid. 1992. Technological Change and the Concentration of the U.S. General Cargo Port System: 1970-88, *Economic Geography*, 69: 272-289.

Liu, Chiu and Philip Shinbein. 1999. Integration of US Customs Operation and Approach Road Capacity, Paper Prepared for the Transportation Research Board 78th Annual Meeting, Washington, D.C.

Maltz, Arnold B., James R. Giermanski, & David Molina. 1996. The U.S.-Mexico Cross-Border Freight Market: Prospects for Mexican Truckers, *Transportation Journal*, Fall, p. 5-19.

Matranga, Eric & John Semmens. 2000. *Traffic and Expenditures on Arizona State Highways.* Arizona Department of Transportation.

McCray, John P. and Robert Harrison. 1999. NAFTA Trucks on U.S. Highway Corridors, Paper Prepared for the Transportation Research Board 78th Annual Meeting, Washington, D.C.

Murphy, Paul R. & Patricia K. Hall. 1995. The Relative Importance of Cost and Service in Freight Transportation Choice Before and After Deregulation: An Update. *Freight Transport Choice*, Fall.

Owusu-Antwi, Emmanuel. 1999. Personal Interview.

Radwan, Essam A. & Jeffrey Cochran, Martin Farris. 1987. *Arizona Freight Network Analysis: a Report to the Transportation Planning Division, Arizona Department of Transportation,* The Center for Advanced Research in Transportation, Arizona State University.

Reed, John. 1996. Impediments to Intermodal Freight Transportation Identified, *ITE Journal*, February. 22-23.

South, Robert. 1990. Transnational 'Maquiladora' Location , *Annals of the Association of American Geographers*, 80(4), p. 549-570.

Stank, Theodore P. & Michael R. Crum. 1997. Just-In-Time Mnagement and Transportation Service Performance in a Cross-Border Setting, *Transportation Journal*, Spring., p. 31-42.

Sutter, Mary. 1997. Crossing the line: Truckers still frustrated by closed border, *Business Mexico*, March, p.32-35.

Sutter, Mary. 1996. Mexico focuses on privatizing transport as dispute delays U.S. border opening, *Traffic World*, Jan. 1, p. 17-18.

United States General Accounting Office. 1993. *Longer Combination Trucks: Driver Controls and Equipment Inspection Should Be Improved*. Washington D.C., November.

United States General Accounting Office. 1996. *Commercial Trucking: Safety and Infrastructure Issues Under the North American Free Trade Agreement.* Washington D.C., February.

United States General Accounting Office. 1997. *Commercial Trucking: Safety Concerns About Mexican Trucks Remain even as Inspection Activity Increases*. Washington D.C., April.

Williams, Billy M. & Lester A. Hoel. 1998. Freight Planning Requirements for Interstate Corridors, *Transportation Quarterly*, v. 52, n. 2, p. 39-48.

Zaniewski, John and Michael Mamlouk. 1999. Pavement Preventive Maintenance: The Key To Quality Highways, Paper Prepared for the Transportation Research Board Annual Meeting, Washington, D.C.